

Geostationary Coastal Ecosystem Dynamics Imager (GEO CEDI) for
the GEO Coastal and Air Pollution Events (GEO CAPE) Mission

~ Concept Presentation ~

Overview Presentation

By

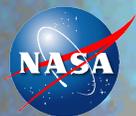
IDL Study Team

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January 29, 2010



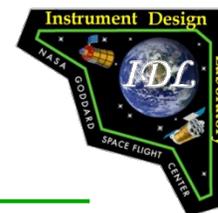
GEO-CAPE Mission Overview



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- Mission Configuration A:
 - GEO-CEDI (Coastal Ecosystem Dynamics Imager)
 - GEO-MAC
 - CISR (Compact Imaging Spectro-Radiometer)
- Mission Configuration B:
 - GEO-CEDI only
- Mission Class: B
- Launch Date: 2017
- Launch Vehicle: Undetermined
- Orbit: Geostationary 95W Longitude
- Science FOR: 50N Lat to 45S Lat / ~160W Long to ~30W Long





Primary Science Requirements

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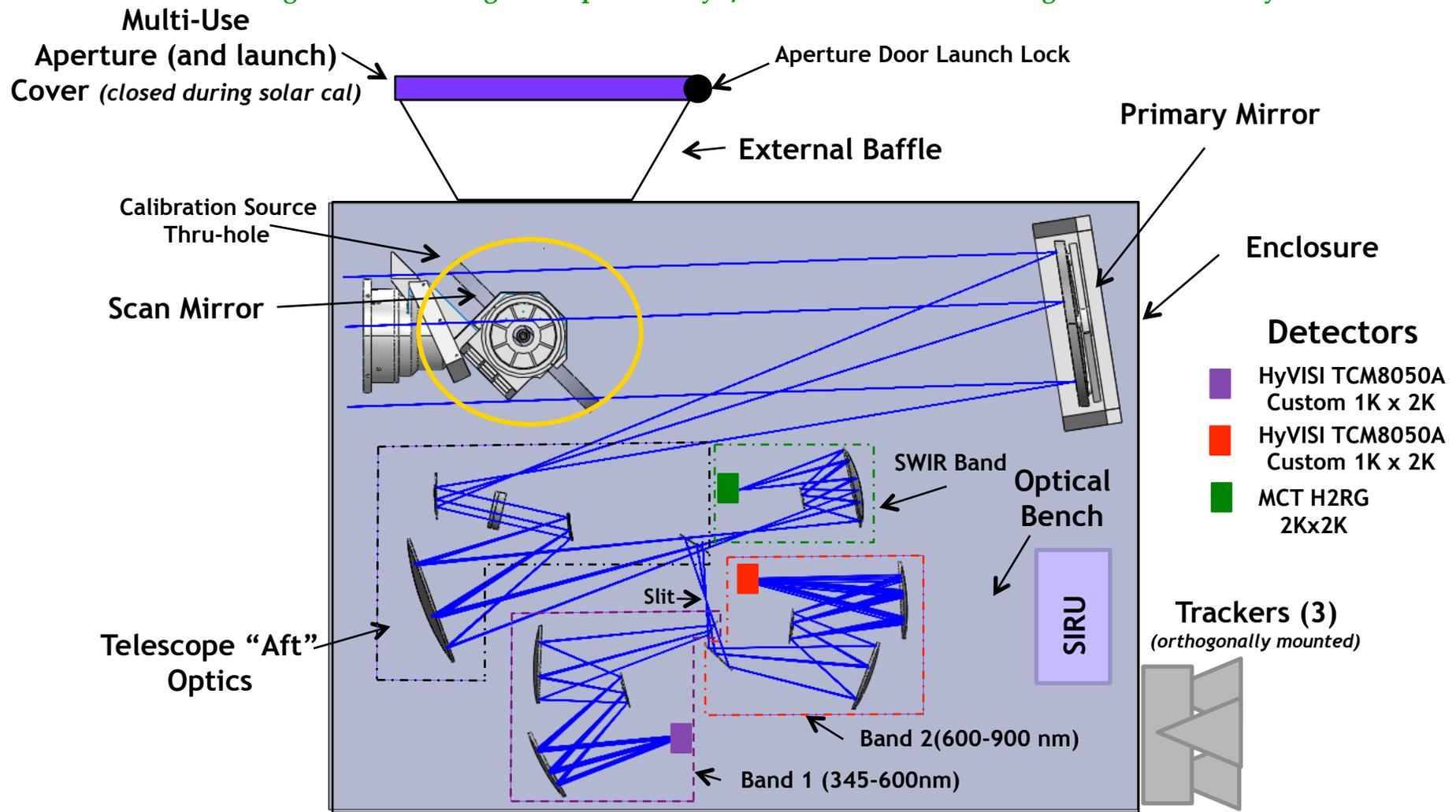
- **Scan of U.S. Coastal Water 3x day during daylight hours**
 - Other Regions of Interest from 50 N Lat to 45 S Lat
- **Spatial resolution**
 - 375m x 375m per pix
 - Goal of 250m x 250 m per pix
- **Coverage area**
 - 300 km
 - Goal of 500 km
- **Spectral Range**
 - Hyperspectral UV-VIS-NIR; Multispectral SWIR
 - 345-900 nm; SWIR bands: 1245, 1640 & 2135 nm
 - Goal of 340-1100 nm; SWIR bands: 1245, 1640 & 2135 nm
- **Calibration**
 - Onboard Lunar and Solar Calibration
 - No internal wavelength sources
 - Each camera head includes several LEDs for flood lamp calibration





Coastal Ecosystem Dynamics Imager (CEDI) Block Diagram

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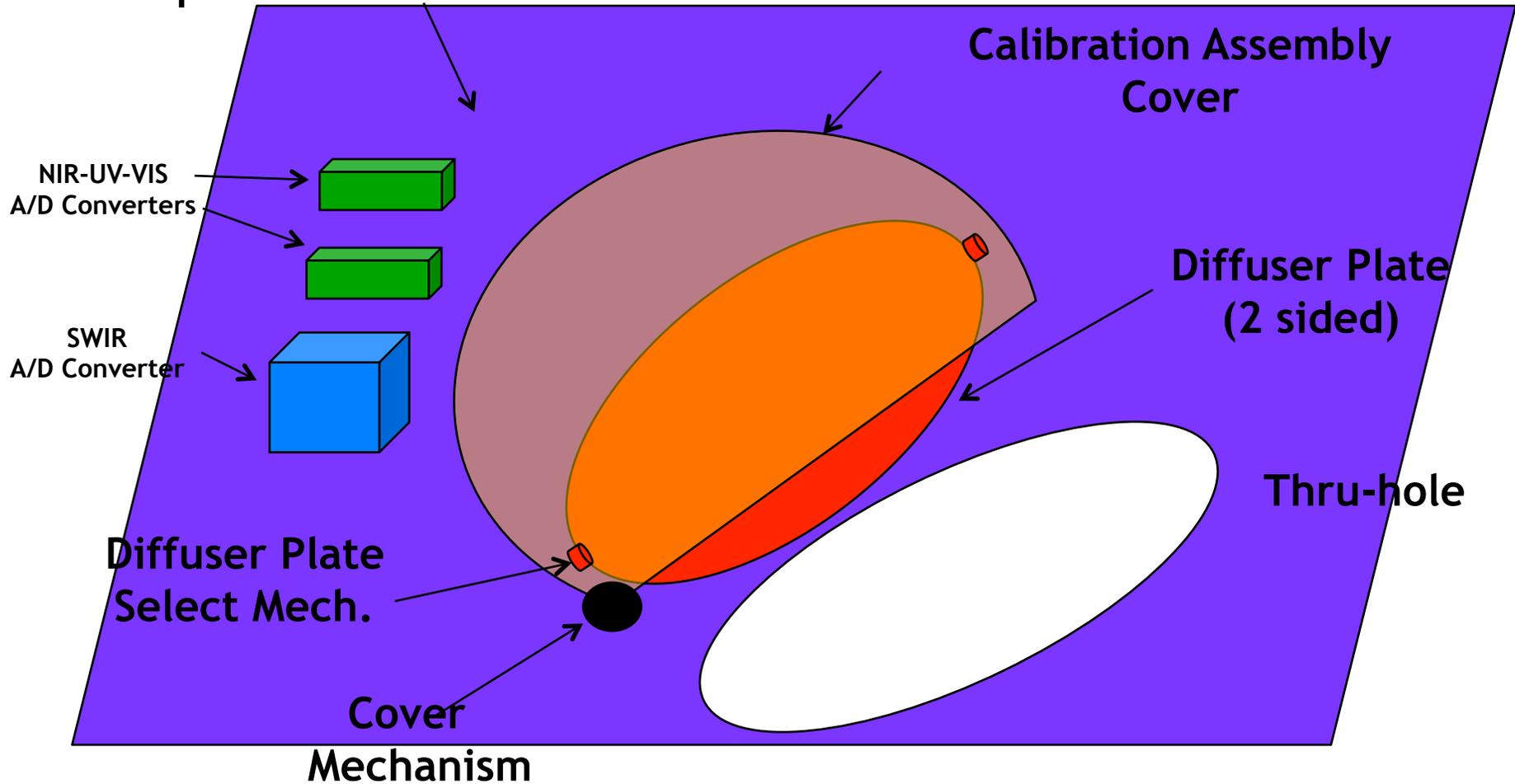


Coastal Ecosystem Dynamics Imager (CEDI) Block Diagram - Part 2



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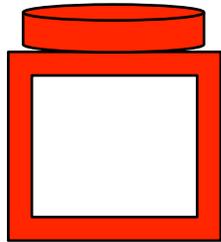
Top Deck of GEO-CEDI



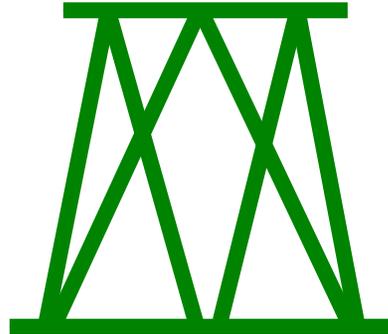
Coastal Ecosystem Dynamics Imager (Other Assemblies For CEDI “Only” Configuration)



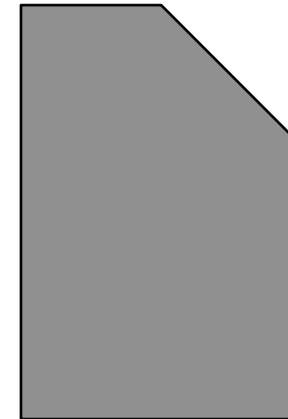
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Calibration
Assembly
(on instrument
enclosure)



Stewart Platform



Small
Strongback
Assembly



CEDI Main Electronics Box
(A/B - internally redundant,
mounted on spacecraft)

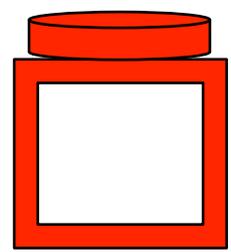
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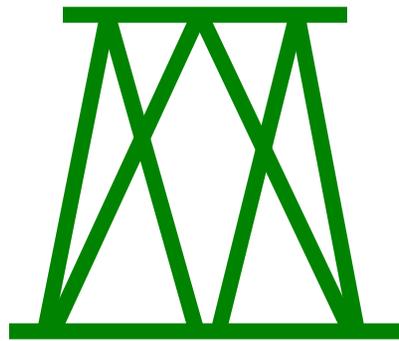


Coastal Ecosystem Dynamics Imager (Other Assemblies For GEO CAPE “Suite” Configuration)

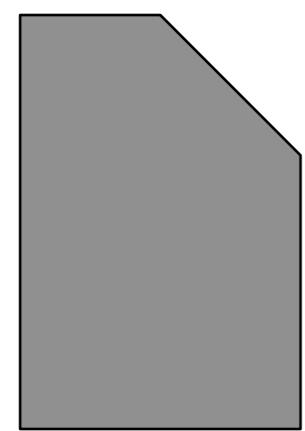
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Calibration Assembly
(on instrument enclosure)

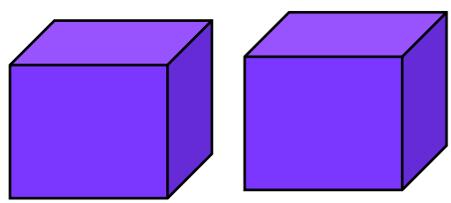


Stewart Platform



Large Strongback Assembly

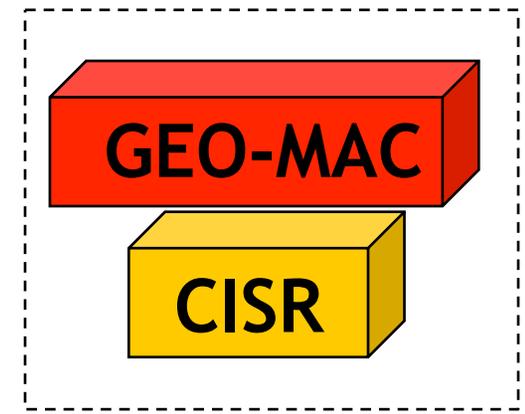
Payload C&DH Boxes
(A and B)
(on spacecraft)



CEDI Main Electronics Box
(A/B - internally redundant,
mounted on spacecraft)



Not costed in this study
No provision for
Thermal control



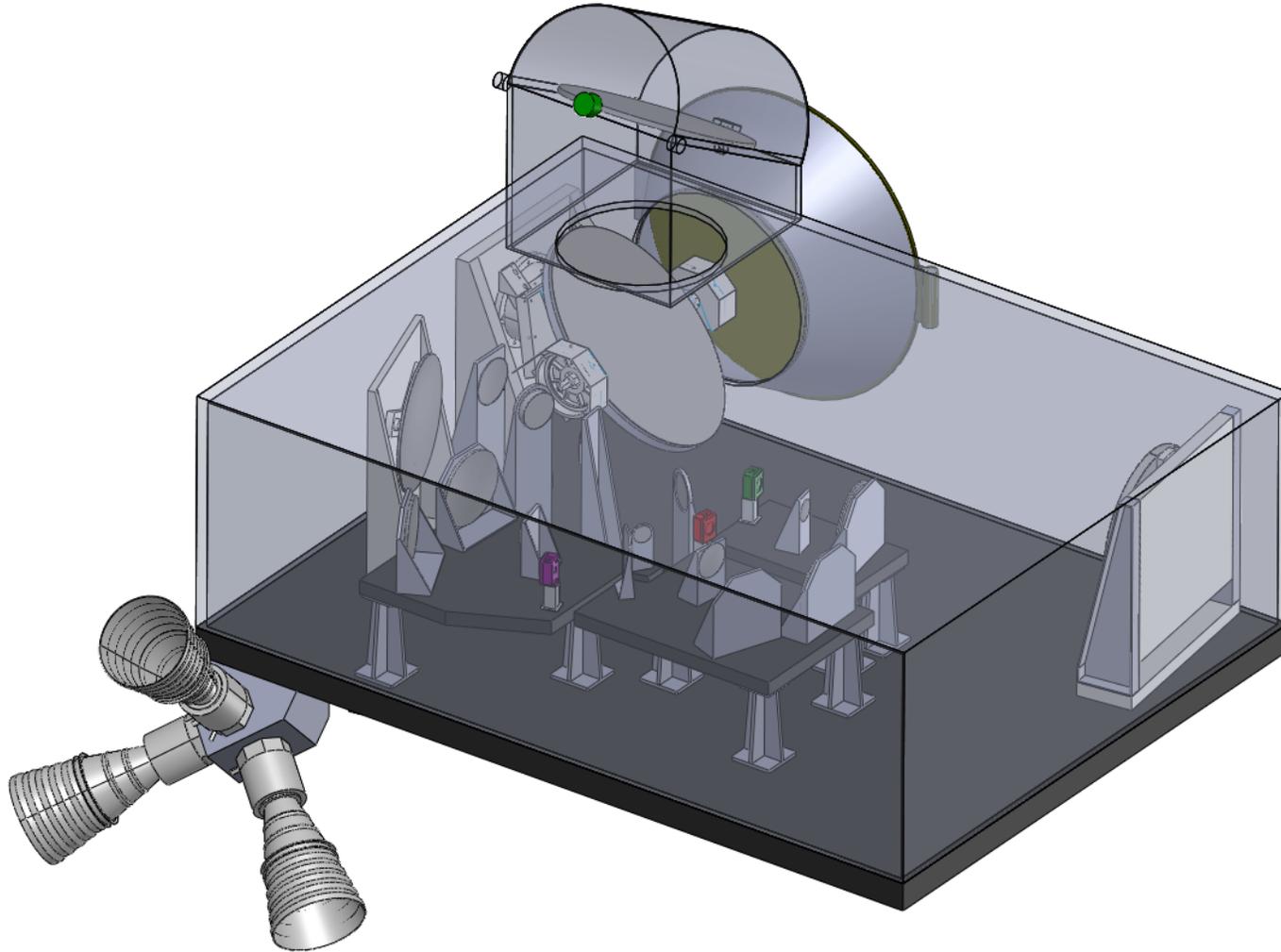
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GEO-CAPE Mechanical Configuration



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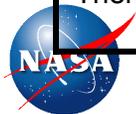


Total Instrument Rack-up (no contingency included)



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GEO-CAPE (CEDI) Instrument Assemblies	Total Mass	Total Power	Total Data Rate
CEDI Aperture Cover Mechanism Scan Mirror Assembly Telescope Assembly Slit Band 1 (340-600nm) Assembly Band 2 (600-900nm) Assembly SWIR Assembly Calibration Assembly Enclosure External Baffle Optical Bench Star Trackers (3) SIRU CEDI Main Electronics Box Strongback (small) Stewart Platform Additional GEO-CAPE Suite Assemblies Payload C&DH CISR GEO-MAC Thermal Subsystem	<p>CEDI Only 621.4 kg Details on page 15, 16</p> <p>GEO-CAPE Suite 852.6 kg Details on page 15</p>	<p>CEDI Only 392 W Details on page 19</p>	<p>CEDI Only 88.4 Mbps Details on page 18</p>



Design Discussions / Design Evolution



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• Detectors

- Essentially no change in detector performance specs from last study
- Adopting MCT H2RG 2Kx2K simply because that form factor is “off-the-shelf”
- Assuming UV-VIS-NIR detector is custom 1Kx2K form factor of the TCM8050A
- Assuming read out rates of 2.62 MHz and 1.25 MHz respectively

• Optics

- Design developed assuming 375m spatial resolution per pixel which allowed implementation of a 0.5 m Primary and shrinking of optical the layout reducing the volume of the MDI (now CEDI) instrument
 - Was 15.3 m³ (including calibration assembly)
 - Is 7.5 m³ (including calibration assembly)
- UV-VIS-NIR split into 2 bands
 - 345 nm to 600 nm
 - 600 nm to 900 nm (up to 1100 nm achievable optically but the QE of the detector is very low after 1 micron)
 - Optics presentation will provide commentary on implications of achieving a 300m spatial resolution



Design Discussions / Design Evolution



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- **Solar Calibration Assembly**

- Previous study inserted calibration source into optics train beyond the scan mirror and primary mirror and therefore was relatively small compared to current implementation
- Current calibration system incorporates a reflective diffuser plate (spectralon) in a “pop-up” configuration that illuminates the entire scan mirror and primary mirror
 - “Lazy-Susan” approach abandoned in favor of smaller “pop-up” configuration
- Note: The spectralon diffuser plate is larger than 15 cm and thus requires a trade study as precision hardware of that size has little heritage.

- **GEO-CEDI Mechanisms**

- Reusable Aperture Door / launch lock
- Scan Mirror (2DOF)/ launch lock(2)
- Calibration Assembly Cover / launch lock
- Diffuser Plate Select Mechanism / launch lock

- **GEO-CAPE Suite Mechanical**

- Mounting is similar to GEO-MDI configuration
- Strongback size has been scaled back in keeping with reduction in size of CEDI; updated mass to be provided



Design Discussions / Design Evolution



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- **ACS**

- Increased the number of Star Trackers from 2 to 3
 - Note: We are assuming the same Star Trackers from GEO-MDI study (BALL CT-602)
 - Other smaller and cheaper options are available (e.g. DTU micro-Astro Stellar Camera)
- Provides redundancy and ability to maintain pointing requirements in the event of a Star Tracker Failure
- Assuming a Stewart platform is required for GEO-CEDI standalone and GEO-CAPE Suite configurations
 - We did not reevaluate or resize the platform from the GEO MDI study
 - Passive, 6 DOF Stewart platform was recommended for the GEO-CEDI standalone configuration

- **Electronics**

- Assuming internally redundant CEDI Main Electronics Box
- Assuming redundant Payload C&DH boxes (GEO-CAPE Suite configuration only)



Design Discussions / Design Evolution



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- **GEO-CEDI Solo Mechanical**

- Current design would also require a strongback (assuming top mounting to spacecraft)
- Orientation of slit must be maintained w/r/t earth
- Rotation of instrument would necessitate reorientation of optics

- **Instrument Processing Capability**

- Driven by ACS System / Scan Mirror control loop interface
 - 100 Hz scan mirror control is the maximum capacity of the 133MHz BAE Rad750, given other nominal 1Hz processing responsibilities
- Assuming 750RAD Processor as current “line-in-the-sand”
 - Expect new technology available before instrument design/development starts





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SCS-2 SYSTEMS PRESENTATION PART II



CEDI

Mass Summary by Subsystem



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IDL provides cost estimates based on Current Best Estimate (CBE) of mass; mass margin and contingency is accounted for in the Integrated Design Center's Mission Design Lab (MDL), otherwise the customer must account for this additional mass

Subsystem*	CEDI Mass CBE (kg)	% of Total Mass	MDI Mass CBE (kg)	% of Total Mass
Optical	36.1	5.8%	81.8	8.7%
Detector	0.2	0.0%	0.141	0.0%
Mechanism	38.5	6.2%	74.6	7.9%
Mechanical	378	60.8%	598.1	63.3%
Electrical	15.4	2.5%	10.0	2.6%
Harness	9.9	1.6%		0.0%
ACS	22.5	3.6%	25.2	2.7%
Thermal	71.6	11.5%	140.9	14.9%
Contamination	10	1.6%	0.0	0.0%
5% misc Hardware	39.2	6.3%	0.0	0.0%
Total (+ 5% hardware and no margin):	621.4	100%	930.7	100%

*this listing does not include all subassemblies, please refer to the final mass model (MEL) for a full summary

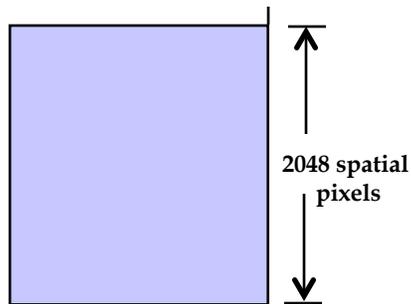


UV/VIS & VIS/NIR Detector Assumptions & Data Rate



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Array (1Kx2K)pix



1024 spectral pixels

Detector Assumptions

- 2 (1Kx2K) Custom Detector Arrays, 8 outputs each (ie. 0.25Mpix each output)
- Readout [1K (spectral) x 2K (spatial)] pix.
- Frame transfer readout capability.

Readout Assumptions

- 4 frames @ 200mSec integration period
- 14 bits/pix resolution

Data Rate Calculations

- ⇒ ADC Sample rate = $0.25\text{Mpix}/0.2\text{sec} = 1.25\text{Mpix/sec}$ (ie. 1.25MHz sample rate)
- ⇒ Readout Rate ~ $(1.25\text{Mpix/sec}) \times 14\text{bits/pix} \sim 17.5\text{Mbps}$ each output
- ⇒ 140Mbps total for all 8 outputs

Co-Add 4 frames

- ⇒ Data Rate ~ $140\text{Mbps}/4 \sim 35\text{Mbps}$ each detector

⇒ **70Mbps** total for both detectors

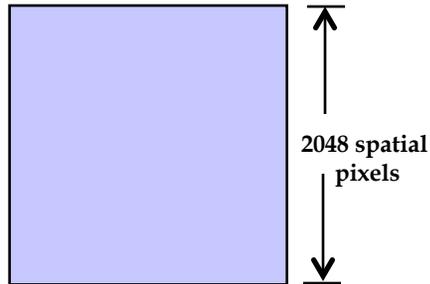


SWIR Detector Assumptions & Data Rate



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Array (512x2K)pix



512 spectral pixels

Detector Assumptions

- 1 (2Kx2K) Detector Array, 32 outputs (ie. 0.125Mpix each output)
- Readout [512 (spectral) x 2K (spatial)] pix.
- Frame transfer readout capability.

Readout Assumptions

- 64 frames @ 12.5mSec integration period
- (64 x 512)pixels each of 32 outputs (ie. 0.0328Mpix each output)
- 14 bits/pix resolution

Data Rate Calculations

- ⇒ ADC Sample rate = $0.0328\text{Mpix}/0.0125\text{sec} = 2.62\text{Mpix/sec}$ (ie. 2.62MHz sample rate)
- ⇒ Readout Rate ~ $(2.62\text{Mpix/sec}) \times 14\text{bits/pix} \sim 36.7\text{Mbps}$ each output
- ⇒ 1.17Gbps total for all 32 outputs

Co-Add 64frames

⇒ Data Rate ~ $1.17\text{Gbps}/64 \sim 18.4\text{Mbps}$ for downlink

⇒ **CEDI Instrument Total: ~ (70+18.4)Mbps ~ 88.4Mbps**



CEDI Main Electronics Box Summary



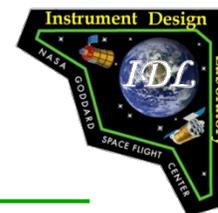
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Circuit Boards (8"x6"), 0.5Kg each	QTY	Avg. PWR (Watts)	Mass (Kg)	Description	% Analog/ Digital
Instrument Processor Board	1A/1B	8.5	1.0	PowerPC750	5/90
Thermal Control	1A/1B	4.0	1.0	3 circuits each	70/25
Scan Motor Control (2DOF)	2A/2B	5.0	2.0		70/25
Aperture Motor Control	1A/1B	5.0	1.0		70/25
Cal. Assembly Motor Control	1A/1B	5.0	1.0	Output switched between 2 motors	70/25
Housekeeping	1A/1B	5.0	1.0	Temp, Voltages, Currents	70/25
* Power Converter (Assume 75% efficiency)	1A/1B	23.3	1.0		90/5
Backplane	1A/1B	-	1.4		0/0
Housing	1	-	2.9		
Total	-	55.8	12.3		

Box Estimate: (23 x 18 x 43)cm, ~ 55.8Watts, 12.3Kg (ie. 9.4Kg board total + 2.9Kg Housing)

Note: This box is internally redundant (ie. 8 prime boards with backplane plus 8 redundant cold standby boards)





GEO-CEDI Power Requirement Summary

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Spacecraft Power Bus Requirement

Load	Avg. Power (Watts)
Payload C&DH Box	25.0
CEDI Main Electronics Box	55.8
Detectors, FET Drivers & Digitizer Boards (3)	21.0
Scan Mirror Motors (1 of 2 ON at a time)	13.0
Heaters (actively controlled)	3.0
Heaters (thermost controlled)	300.0
CEDI Only Instrument Total:	392.0

Note:

- Total does not include ACS components or Payload C&DH Box, which are powered by the Spacecraft
- Total does not include survival heater power (222 to 317W) to the CEDI instrument which is also powered directly by the spacecraft
- The CEDI detector heater control power (actively controlled) is shown here as 3W, and is estimated in the thermal model to be between 4.5W (orbit average) and 6.4W (peak)
- The CEDI operating heater power (thermostat controlled) is shown here as 300W, and is estimated in the thermal model to be between 250W (orbit average) and 375W (peak)
- The CEDI instrument will require the X-band downlink interface in the Payload C&DH box; this interface could be placed in either the CEDI MEB or the Spacecraft if the Payload C&DH box is not flown.



Changes to GEO MDI 2006 Configuration & Rationale

(1 of 3)



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DESIGN CHANGES from GEO MDI to CEDI

- Implemented customer's degraded spatial and spectral resolution requirements to realize a significant volume savings in the entire optical assembly, as well as the 3 channels
- Implemented a calibration housing that includes all optics in the lunar and solar calibration, and provides full aperture illumination from a frequent and an infrequent diffuser surface
 - The previous diffuser housing did not illuminate the primary mirror and was injected downstream in the instrument to minimize volume
 - Eliminated the flip mirror in the GEO MDI design that initiated the calibration mode
- Implemented a detector readout scheme that meets SNR goals and eliminates saturation in critical channels in the SWIR channel
 - This increased the number of readout boards in the SWIR digitizer box, but they are identical, so there is an NRE savings
- Considered the CEDI MEB and Payload C&DH electrical boxes in the thermal budget for survival heater power; previously these were not addressed as it was assumed they were mounted directly to the S/C
- Costed the redundant electronics for the CEDI MEB and Payload C&DH; previously it was intended that these electronics were redundant, but they were not costed
- Added a 3rd star tracker for redundancy (only 2 operate simultaneously)
 - Confirmed the mass of the CT-602 star tracker, but allocated the additional 1.1kg as baffle mass where it was previously designated as electronics associated with the tracker



Changes to GEO MDI 2006 Configuration & Rationale

(2 of 3)



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DESIGN CHANGES from GEO MDI to CEDI *continued*

- Scaled the strong back for both CEDI-alone (small strongback) and GEO CAPE Suite (large strongback) configurations
 - Confirmed that the preliminary structural assessment of the strongback indicated that the scale was appropriate in the original design
 - Confirmed that the CEDI-alone configuration would also need to be edge-mounted and require a similar strongback
- Eliminated calibration lamp sources from previous mass model and replaced them with camera-mounted LEDs as flood lamp calibrators
- Implemented lightweight structural materials (M55J graphic/epoxy and honeycomb) to save mass over Al, wherever possible, as proposed in the MDI design
- Incorporated updated volume/mass estimates for CISR, as provided by the customer team, in our mass and mechanical models (GEO MAC remained the same as it was shown in 2006)
- Confirmed that the instrument-mounted ACS components are necessary for the closed-loop operation of the scan mirror and have accounted for that flight software control in our grassroots cost estimate
 - Maintained a Rad750 PowerPC processor within the CEDI MEB as was proposed for MDI in 2006
- Eliminated a filter wheel mechanism from the 2006 version and replaced it with a dispersive element in the SWIR channel and detector mounted filters (3)
- Have assumed Class S electronic parts for CEDI to be consistent with the high reliability parts recommended for a Class B mission (or the labor to upscreen lower quality parts when necessary); Class B parts were modeled for MDI in 2006



Changes to GEO MDI 2006 Configuration & Rationale

(3 of 3)



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DESIGN CHANGES from GEO MDI to CEDI *continued*

- Have shown the detector digitizer boxes mounted to the instrument enclosure (as they were intended for MDI in 2006, but time did not permit adding those details to the mechanical model)
- Assumed the same instrument lifecycle (development) schedule, but moved it forward to 2013
- Accounted for thermal blankets to cover the strong back, but have not provided active temperature control (although it is anticipated that the GEO MAC & CISR instruments would benefit from the CEDI-mounted ACS hardware)

DESIGN CONSIDERATIONS that may need to be revisited in the future, but were not undertaken in the CEDI study

- Did not (re)evaluate the specific star tracker or SIRU chosen for GEO MDI
- Did not (re)evaluate the specific Stewart platform recommended for GEO MDI
- Did not (re)evaluate the Payload C&DH function or capability proposed for GEO MDI as we did not discuss the GEO MAC or CISR processing or interface needs

